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Limestone Screenings as a Substitute for Sand In Concrete

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LIMESTONE SCREENINGS

AS

A SUBSTITUTE FOR SAND IN CONCRETE

BY

CURTIS CORNELIUS WESTFALL

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This is to certify that the following thesis prepared under the immediate direction of Mr. L. G. Parker, Instructor in Civil Engineering, by

CURTIS CORNELIUS WESTFALL

entitled LIMESTONE SCREENINGS AS A SUBSTITUTE FOR SAND IN CONCRETE

is accepted by me as fulfilling this part of the requirements for the Degree of Bachelor of Science in Civil Engineering.

Ira O. Baker

Head of Department of Civil Engineering

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Limestone Screenings as a Substitute for Sand in Concrete.

Concrete is rapidly gaining favor as a substitute for stone masonry. In foundations, bridge piers, and abutments, and even buildings, its convenient form, as well as its strength, make it a popular material of construction.

The usual ingredients of concrete are cement, sand, and broken stone or pebbles. In a large portion of Illinois, and in portions of a considerable number of other states in the Mississippi Valley, it is difficult to find sand suitable for use in mortar and concrete. Further, in the preparation of the crushed stone for use in concrete, a considerable amount of fine material is produced. Formerly it

was the custom to waste these screenings; but latterly the claim has been made that such screenings are a suitable substitute for sand in mortar or concrete. If this material could be substituted for sand in the making of concrete, the expense of concrete structures would be greatly diminished, as an otherwise worthless article would be used in place of one difficult to get and having commercial value. It was therefore proposed to make experiments to determine the relative values of sand and screenings as ingredients of mortar and concrete.

Two series of experiments were made. The first was a test of the strength of mortars made with screenings as compared with the strength

of mortars made with sand. In the second series, the strength of concrete beams made with screenings was compared with the strength of similar beams in which sand was used.

The cement used in these tests was Chicago AA Portland, which is recognized as a standard grade.

The screenings and stone were of a good grade of limestone from the penitentiary at Joliet.

A rough sieve analysis showed that all of the screenings passed a three-quarter inch mesh, while about 54% of them was caught on a quarter-inch sieve. Of that portion which passed the latter sieve, a considerable amount was fine dust.

The broken stone used in

the concrete was of sizes between three-quarters of an inch and two inches.

The sand was good, sharp silica sand, of a much better grade than is ordinarily obtained in the Mississippi Valley. It was screened through a ¼-inch mesh.

Briquette Tests.

In the first series of experiments, briquettes were made of standard form in the Olsen press, thus insuring uniform conditions. The briquettes were allowed to stand 24 hours in the air, and were then stored in water until broken. In the first two sets of briquettes, screenings less than one-quarter inch in size were used; but in the third set the screen-

ings ran in size up to three-quarters of an inch. In making the sand mortars 9.8% of water was used in the 1:3 mixture, and 10.6% in the 1:2 mixture. The mortars made with screenings required a slightly larger per cent of water.

Table I, page 12, shows the results of tests on briquettes made of 1:2 mortars broken at the ages of 1, 4, and 12 weeks respectively. Table II gives the breaking loads of 1:3 briquettes of the same ages as the above. Table III shows the strength of mortars one week old, made of crusher-run screenings instead of screenings passing a quarter-inch mesh.

A comparison of the results given in the above tables shows that where the

finer screenings were used, the mortars were in every instance stronger than the corresponding sand mixtures. For the 1:2 mortars the excess strength is: at one week 7%, at four weeks 4%, and at twelve weeks 30%; and for the 1:3 mortar; at one week 20%, at four weeks 28%, and at twelve weeks 19%.

Table III shows that the coarser screenings give results substantially the same as for the finer screenings. Since the coarse screenings give as great strength as the fine screenings, it is immaterial which is used, therefore the choice will depend upon the price. The last statement is not strictly true for mortar in masonry having close joints; but is true for the mortar to be used in

making concrete.

From these results it would seem that the screenings might well be substituted for sand, for upon the strength of the mortar depends the strength of the concrete.

Beam Tests.

In the beam tests, the concrete was made into beams 6"x6"x28". The method of making the beams was the same for all. The concrete was made quite wet and was well tamped. The beams were tested on knife-edge supports 22" apart, and the load was applied through a knife-edge at the middle. When the surface of a beam was so rough that it gave a poor bearing for the knife-

edges, a bed of plaster of Paris was spread on it, thus insuring an equal distribution of the load.

Beams were made, in sets of three each, of cement, screenings, and stone, in the proportions 1-2-4, 1-3-6, 1-3-3, 1-2-5, 1-3-4, and 1-4-3. Beams were also made of 1-2-4 and 1-3-6 mixtures using sand instead of screenings, to afford a comparison between the two forms of concrete. The results for all of the beam tests are given in Table IV.

The first part of this table shows that a 1-2-4 screenings concrete averages 60% stronger than a similar concrete using sand instead of screenings; and a 1-3-6 screenings concrete is 17.6% stronger than the corresponding sand concrete.

The strength of the beams of the 1-3-3, 1-2-5, 1-3-4, and 1-4-3 combinations was determined to show the merits of the different mixtures of screenings.

Of all the beams, as would be expected, those made of the 1-2-4 mixture were strongest, having an average breaking load of 2943 pounds; next came the 1-3-3 mixture with a breaking load of 1638 pounds, and then the 1-3-6 composition, which stood 1148 pounds. The 1-2-5, 1-3-4, and 1-4-3 mixtures ran very much lower for some unknown cause. These latter proportions should all have been stronger than the 1-3-6, as they all contained more cement, in proportion to the aggregate, than did the latter. They are, however, consistent among

themselves, in that they ranged in strength according to the richness of the mortars, the 1-2-5 ranking first, with an average breaking load of 738 pounds, the 1-3-4 second with 412 pounds, and the 1-4-3 last with 400 pounds. It is interesting to note that the six sets of beams made of screenings may be divided into two groups, differing materially in average strength, as follows:

Group 1.		Group 2.	
1-2-4	2943 lb.	1-2-5	738 lb.
1-3-3	1638 "	1-3-4	412 "
1-3-6	1148 "	1-4-3	400 "
average	1909 "	average	517 "

The difference in strength is probably due to a difference in storage. The beams in the first group were made earlier in the Spring and

were stored in a colder room than were the latter. Owing to this difference in storage, the first group of beams lost less water by evaporation.

Conclusion

Since the mortars in which screenings were used showed greater strength than the sand mortars of the same proportions, it seems that screenings are superior to sand as an ingredient of concrete. The tests of the 1-2-4 and 1-3-6 beams show that concrete made with screenings is better than that made with sand. Therefore we may conclude that limestone screenings are better than good silica sand for use in mortar or concrete.

Table I.

Strength of Briquettes of 1:2 Mortars.

Results in lbs.

Ref. No.	1 week old.		4 weeks old.		12 weeks old.	
	sand	¼ inch screen	sand	¼ inch screen	sand	¼ inch screen
1	337	294	402	372	450	495
2	283	277	434	396	440	605
3	214	295	366	370	466	615
4	235	292	322	415	467	505
5	321	265	300	387	430	650
6	206	283	422	370	420	608
Av.	266	285	374	385	446	580

Table II.

Strength of Briquettes of 1:3 Mortars.

Results in lbs.

Ref. No.	1 week old.		4 weeks old.		12 weeks old.	
	sand	¼ inch screen	sand	¼ inch screen	sand	¼ inch screen
1	232	218	285	308	360	410
2	175	208	150	310	365	465
3	227	256	250	312	390	454
4	174	241	250	285	400	422
5	210	240	240	275	340	426
6	138	226	275	370	345	446
Av	193	232	242	310	367	437

Table III.

Strength of Briquettes of Mortars Made of Crusher-Run Screenings.

Age 1 Week. Results in lbs. per sq. in.

Ref. No.	1-2		1-3	
	Sand	Screen'g	Sand	Screen'g
1	337	375	232	195
2	283	273	175	160
3	214	312	227	170
4	235	242	174	235
5	321	260	210	290
6	206	265	138	245
Av.	266	288	193	216

Table IV.

Strength of Concrete Beams 60 Days Old.

Ref. No.	1-2-4				1-3-6				1-3-3		1-2-5		1-3-4		1-4-3	
	Sand		Screen.		Sand		Screen.		screenings							
	Breaking load lbs.	Mod. rup. lbs. sq.in.	Breaking load lbs.	Mod rup. lbs. sq.in.	Breaking load lbs.	Mod. rup. lbs. sq.in.	Breaking load lbs.	Mod. rup. lbs. sq.in.	Breaking load lbs.	Mod. rup. lbs. sq.in.	Breaking load lbs.	Mod. rup. lbs. sq.in.	Breaking load lbs.	Mod rup lbs. sq.in.	Breaking load lbs.	Mod. rup. lbs. sq.in.
1	2010	305	3530	541	520	80	900	125	1395	213	955	145	335	51	400	61
2	1740	266	2800	428	1090	166	1490	207	1695	259	870	133	490	75	*	
3	1730	265	2500	382	1320	205	1055	161	1825	278	390	58	*		*	
Av.	1826	278	2943	450	976	150	1148	176	1638	250	738	113	412	63	400	61

* Broke in handling.